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Designing for the Clothed Man

Even in push-button warfare someone must be able to push the button

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THE RAPIDITY of technological advancement in recent years has resulted in the production of increasingly complex military equipment. The capabilities of men who must operate some of this equipment are frequently strained and at times surpassed. Man's ingenuity in creating machines which transcend his ability to operate them and experience from past wars have brought home the realization that a weapon is only as good as its human operator. A tank, for example, is an efficient fighting machine only if the crew operates appropriate controls in the proper sequence. Occasionally weapons systems fail in their tasks because of errors by the operators, but the human error is often greatly magnified by the design of the machines. The frequency with which the theoretical effectiveness of machine systems is reduced by virtue of control requirements which are incompatible with the capacities of the human operators has led to a movement in the direction of tailoring military machines to fit the man.

Although military design engineers have accepted the concept of designing man-machine systems, there is a tendency to overlook the fact that there is a third important element, the environment. The research philosophy of the Quartermaster Research and Development Center is predicated upon the recognition that military research and development problems can be described and delineated in terms of the interactions of man-equipment-environment systems. That is, any military activity involves a finite number of trained men setting out to accomplish a specified military goal while wearing, carrying and operating various items of clothing, equipment, and weapons under varying conditions which are imposed both by nature and by the enemy. An equivalent statement is that a finite number of man-machine systems operating under varying environmental conditions is attempting to accomplish a specified military goal.

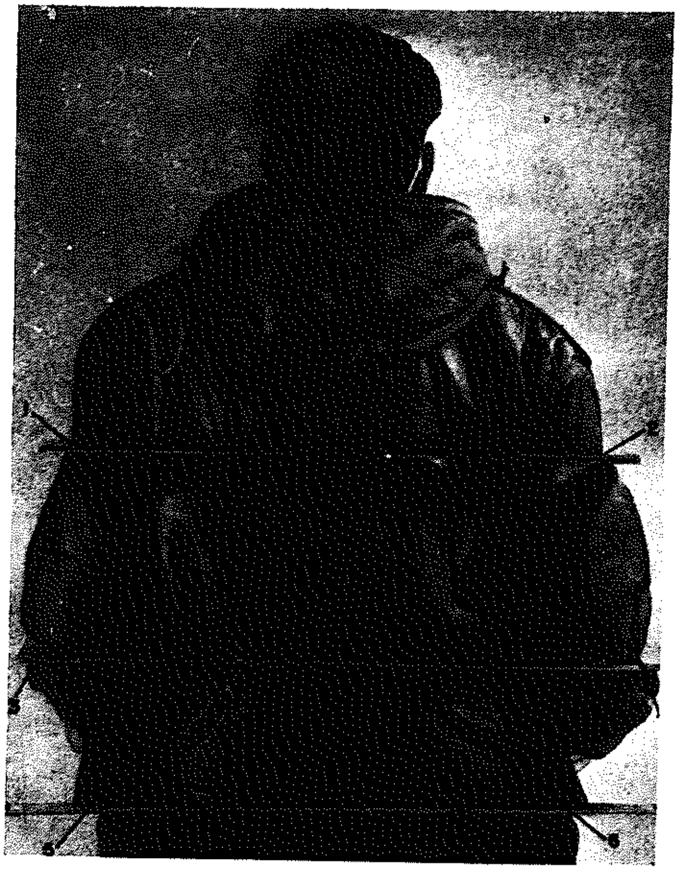
Approximate girth increases in inches wearing functional clothing

Measurements	Fatigues	Cold-Wet	Cold-Dry
A Shoulder	1.5	7	12
B Chest	1	5	8
C Waist	2	8	13
D Hip	1	7	12

Within this frame of reference military materiel may be classified into three major categories: (1) *Machine-served devices,* such as magnetic mines and guided missiles, which are automatically regulated; (2) *Operator-served devices,* such as tanks and most weapons, which require the services of a soldier-operator in order to function; and (3) *Operator-protective devices,* or those, such as clothing, body armor, and gas masks, which are designed to increase the range and the degree of efficiency with which a soldier-operator can function under natural and enemy imposed conditions.

The soldier-operator is often the weakest link in a man-machine system because he is susceptible to environmental influences which may have little or no effect upon the machine itself. Therefore, he must be adequately protected against his environment if he is to fulfill effectively his role as a machine operator. Obviously even in push-button warfare someone must be able to push the button. It is largely the responsibility of the Quartermaster Corps to strengthen this weak link, the soldier-operator, by increasing his operational potentialities through the provision of efficient operator-protective devices.

Research and development technologists responsible for designing operator-protective equipment are con-


Approximate width increases in inches wearing functional clothing

Measurements	Fatigues	Cold-Wet	Cold-Dry
1-2 Bideltoid	1	3	5
3-4 Elbow Breadth	2	4	8.5
5-6 Hip Breadth	2	4	5

tinually being reminded by the Quartermaster Corps' Human Engineers that the protected soldier must be able to operate weapons systems. Efficient man-equipment systems become practically impossible, however, if designers of operator-served equipment fail to recognize that their equipment must be operated by a *protected soldier*. Agreement among the designers of both operator-served and operator-protective equipment and operational researchers and planners is required to establish a series of cut-off points at which soldiers can be regarded as "protected" (at accepted calculated risks) and capable of performing under various sets of environmental and operational conditions. Operator-served equipment to be used under a specific set of conditions must be designed for the soldier clad in operator-protective equipment appropriate to those conditions. Operator-served equipment developed for worldwide use, must be designed to accommodate the bulkiest operator-protective equipment.

Extreme climatic conditions make the development and use of adequate operator-protective devices essential. Clothing provides one means of controlling, within limits, the body's heat balance. For all practical purposes, the actual thickness of the clothing system, including entrapped air, determines the rate at which heat can be lost through it. In general, it may be said that thermal insulation increases with bulk. Protection against cold through the use of insulating clothing increases the military potential of soldiers making it possible for them to function at extremely low temperatures. However, the same protection which makes it possible for them to function at all imposes restrictions on their ability to operate. This applies not only to such problems as mobility, dexterity, seat widths, space requirements, hatch dimension, and so on, but also to such others as control knob diameters and the free space between them.

Consider, for example, the requirements of a piece of manually operated equipment for use during the arctic winter. If this equipment is designed so that it can be operated efficiently only with bare hands, it will be inoperable in the arctic since dexterity is related to hand temperature. If the operator is protected with the gear necessary to keep the hand at the required skin temperature, the equipment may still be inoperable because the handgear also imposes limits upon manual dexterity. In order for soldiers operating in the arctic to have *any* manual dexterity, it is necessary to provide protective handgear; however, the degree of dexterity possible with the handgear is severely limited as compared to bare hands at room temperature. For example, in tests run at room temperature it has been found that, as compared to bare-hand performance at the same temperature, there is an average loss in hand dexterity of 39 percent while wearing the wool mitten insert and a loss of 78 percent while wearing the standard arctic mitten. The Quartermaster Corps is now attempting to design handwear that will provide a greater degree of manual dexterity but designers of operator-served equipment must realize that manually-operated equipment may be useless unless it is designed around the degree of dexterity obtainable with the handwear necessary to give adequate hand protection.

To demonstrate the effect of cold-weather clothing on the space requirements of soldier-operators, a pilot study was made of changes in a few major body dimensions caused by the cold-wet and cold-dry clothing ensembles. Due to the small size of the samples used, and the compressible nature of the clothing, the measurements are only approximate. The study was not intended to be definitive, but rather to illustrate to designers of operator-served equipment how such information concerning operator-protective items is pertinent to design problems.

Waist, hip, shoulder and chest circumferences increased considerably (from approximately eight to thirteen inches) when the complete cold-dry ensemble was worn, somewhat less with the cold-wet uniform (five to eight inches) and only slightly with fatigues (one to two inches).

The same order of changes occurred in width dimensions when wearing these same uniforms. For example, there was considerable change with the cold-dry uniform, less with the cold-wet ensemble, and very small changes with the fatigue uniform.

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his personal safety may depend on it. He must habitually carry it with him or keep it within instant reach while on the job so that when a ground alert is sounded he can instantly arm himself and join in driving off a ground attack.

Sixth, a predesignated mobile reserve, composed of the armed crew not placed in perimeter sites and of individual riflemen, must be available at the CP with the necessary transportation to be speedily moved to the point of the attacking force's major effort. Headquarters personnel are the ideal source for this reserve because of their central location and availability.

Seventh, higher headquarters must be informed of the plan that has been implemented so that an over-all plan can be formulated that ties in the fields of fire, roving patrols, sentries and the communications of adjacent units.

This then is the essence of ground security. Take cognizance of the advantages and limitations of terrain, of the manpower limitations imposed by your technical operation, and of the capabilities of the weapons with which your unit is armed. Adapt your standing procedures to these limitations in such a way that they will apply in practically all conceivable situations and indoctrinate your men in their execution. Then put them into effect in every area in which you establish an installation, and dry-run your procedures as soon as possible. Do not lose sight of the fact that ground security is an indivisible part of your operation and that your mission and the welfare of your men may hinge on its effectiveness. One final thought—security is a command responsibility that cannot be delegated. Perform it thoroughly. Check the plan when it is put into effect *yourself*!

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DESIGNING FOR THE CLOTHED MAN

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These data indicate that the cold-wet and cold-dry clothing ensembles substantially change the "body size" of the clothed soldier. This type of information would be critical to the design of a man-containing vehicle for use in the arctic. It illustrates the effect of one class of operator-protective equipment, i.e., cold-weather clothing, on one critical design factor of operator-served equipment, i.e., the space requirements of the operator.

The machine designer must design for the clothed man; the clothing designer must design for the machine operator. Both must know the requirements and conditions of use of the equipment used by the other. There is a point, however, beyond which the designer of operator-protective equipment cannot go. That is the point at which the soldier ceases to be capable of functioning as an operator. When this critical cut-off point of minimum protection has been reached, no further modification of the protective equipment is possible and the designer of operator-served equipment must then design around the limitations of the protected man.

The Quartermaster Corps is conducting an extensive research program to develop ways of meeting the protective requirements of soldiers under all environmental conditions with operator-protective equipment. Much useful information concerning the limitation and capabilities of the soldier when wearing protective equipment is available and should be used by designers of operator-served equipment. Special studies can be made to answer specific design problems. Requests for such information and also information on new developments in operator-served equipment which might influence the design of operator-protective equipment should be directed to: Headquarters, Quartermaster Research and Development Command, Natick, Mass., Attention: Environmental Protection Division.

The Human Engineering Section, Human Resources Branch, of this Division works very closely with the development divisions of the Command to insure that designers of Quartermaster equipment are always aware that the clothed man must operate other equipment. It is urged that designers of other military equipment reorient their thinking in terms of designing for the clothed man.

BEHIND THE NYLON CURTAIN

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the resultant directional shift of internal pressure. This phenomenon is particularly apparent with a flat circular parachute, but is not uncommon with the T-10.

At 130 knots the parachutist falls an average of about 120 feet, and his forward momentum carries him about 400 feet relative distance behind the airplane before final inflation.

The only apparent disadvantage of bag deployment is the bugaboo of twisted suspension lines—which may disorient the jumper after untwisting. The bag may rotate an average of half a turn—rarely more than one and a half turns—and the canopy may turn on deployment, so that when these forces are transmitted down the lines to the paratrooper (who may also have turned or tumbled), the force is sufficient to cause him to twist the lines. The method for overcoming this deficiency has not been fully resolved, but it may be minimized by stressing proper exit technique and the spreading of the risers by the trooper immediately after receiving the opening force.

During opening two distinct shocks are encountered in extremely rapid sequence. The first, or "snatch"